Forage Quality

Differences in Fiber and Carbohydrates between Corn Silage and Alfalfa Hay
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Introduction

Most of the difference in feeding value between the alfalfa hay (**AH**) and corn silage (**CS**) is related to the nutritional implications of their unique fiber and carbohydrate characteristics in AH and CS. Differences in fiber and carbohydrates not only affect intake potential, but also have significant ramifications on digestibility and ruminal function. Understanding these differences offers the opportunity to formulate dairy rations that take advantage of the attributes of these forages. The objectives of this research were to develop universal relationships between chemical components for AH and CS that could be used to compile a feed information reference database and contrast their carbohydrate characteristics and nutritional properties.

Materials and Methods

Compositions of CS provided in Table 1 were derived from relationships among chemical components in a diverse set of 32 corn silages. Alfalfa hay composition was derived from relationships among chemical components obtained from several published data sets and more than 2000 analyses obtained from ten commercial forage testing laboratories from throughout the U.S. Regression techniques were used to adjust for biases among laboratories and data sets to obtain the universal relationships among chemical components that were consistent among sources.

Acid detergent fiber (**ADF**) was used as the base chemical component for each forage quality and all other composition was related to it or to amylase-treated neutral detergent fiber (**aNDF**) to describe a chemical profile for five qualities of AH and CS. The aNDF method uses both heat-stable amylase and sodium sulfite and was designed to measure insoluble fiber in all types of feeds. It is our best estimate of total dietary fiber for dairy cows and the Association of Official Analytical Chemists, International has approved the aNDF method as Official Method 2002.04 - First Action "Amylase-treated Neutral Detergent Fiber in Feeds Using Refluxing in Beakers or Crucibles." This method has been the reference method for proficiency testing by the National Forage Testing Association since 1994, and results indicate that the 150 participating laboratories routinely have standard deviations among labs for aNDF that are similar to those for ADF.

Nonfibrous carbohydrates (**NFC**) can be estimated by subtracting crude protein (**CP**), fat or ether extract (**EE**) and ash from neutral detergent solubles (**NDS** = 100 – aNDF), i.e. NFC = 100 – aNDF – CP – EE – Ash). Starch was measured after heat or alkali gelatinization and enzymatic hydrolysis to glucose, which was measured colorimetrically. Pectin was determined as the sum of uronic aicds or by solubilization in oxalate solutions.

Results and Discussion

The crude protein, ash, crude fat, fiber, and lignin values in Table 1 agree with those of similar qualities of AH found in the 2001 Dairy NRC. The difference between aNDF and ADF is an estimate of hemicellulose, but for AH, this difference is a slight underestimate because 10 to 20% of the pectin is not extracted by acid detergent. The main NFC in alfalfa is pectin, which is about 40 to 50% of the NFC. In AH, quality is primarily a function of plant maturity. As alfalfa matures the proportions of fiber and lignin increase and the proportions of crude protein and NFC decrease. The negative relationship between maturity and nutritional value are greatest for early spring plant growth.

Ash values are higher and acid detergent lignin values are lower for CS reported in Table 1 than those provided in the 2001 Dairy NRC, but ADF and aNDF values are similar, which suggests that NRC results were obtained using the aNDF method. The predominant NFC in CS is starch and CS contains very little pectin or neutral detergent soluble fiber. Corn silage can vary substantially in chemical composition because grain content is variable and related inversely to fiber concentration. Although immature CS typically have lower grain contents, maturity is not as highly related to nutritional quality in CS as it is in other forages. The inverse relationships between fiber or lignin concentration and maturity often do not hold for CS because it is a mixture of grain and stover. The lignin concentration of corn stover increases and its digestibility declines with maturity; however, as corn matures after silking it generates grain that dilutes the concentration and nutritional impact of the maturing stover often resulting in whole plant digestibilities that vary little with maturity.

Contrasts between alfalfa hay and corn silage. Although the fiber concentrations of AH and CS are very similar at the maturities commonly fed to dairy cows, the non-fiber components and lignin concentrations differ significantly. Like most legumes, alfalfa has much a higher (2-3X) concentration of lignin than grasses such as corn, which indicates that its fiber digestibility will be lower. Because CS has much less protein and ash content (30-50% less) than AH and similar fiber concentration, CS has significantly more NFC, especially when it contains normal or higher proportions of grain. Not only is the concentration of NFC different between AH and CS, but also the composition of the NFC is different. In AH, the major carbohydrates in NFC are pectin and other soluble fibers, but in CS the major NFC is starch. Although pectin is rapidly fermented and is included in the NFC fraction, it ferments in the rumen like other fibrous constituents; its fermentation is sensitive to low ruminal pH and it results in the production of acetic acid. Starch fermentation, on the other hand, is less sensitive to ruminal pH and results in the production of propionic and lactic acids in the rumen.

At similar ADF concentrations, AH is similar in digestibility to CS not because its fiber digestibility is superior, but because its aNDF content is lower (10%-units) and NDS content is higher. Typically the aNDF digestibility of AH is only 75-85% of that of CS. However, the NDS in CS may not have 98% digestibility because starch in whole kernels and large fragments can escape digestion unless it has been effectively processed through rollers with a 1-mm clearance or is thoroughly chewed when fed at 1X maintenance. Of the true DM digestibility in AH, only 19-20% comes from digestible fiber compared to 30-34% for processed CS. In both forages, digestible NDS provides the overwhelming majority of DM digestibility. For processed CS, starch alone provides 28-31% of the true DM digestibility, which is similar to the contribution of digestible fiber in CS.

When 25% processed CS is substituted for very high quality AH in a dairy rations the aNDF and

physically effective NDF in the ration increase about 2%-units, NFC remains constant, and pectin decreases about 3%-units. The increase in aNDF content might result in slightly lower DM intakes, which may also be decreased because the rate of digestion of the NDF in CS is about half of that for high quality AH. Some of the expected decrease in intake may be alleviated by the high palatability and the slightly higher energy density of CS-based rations that contain less lignin than AH-based rations. The impact of the decreased pectin content of the ration containing CS is unclear. If the ration was borderline for peNDF and starch concentration, this small change in pectin concentration might have a significant impact. However, the substitution of CS for AH increases the peNDF content of the ration without significantly changing starch content, which results in a ration that should promote efficient ruminal fermentation and maintain milk fat production. It is expected that the rations containing either 25% high quality alfalfa hay or 25% normal corn silage would obtain similar levels of milk production and overall animal performance. A key requirement is that the corn silage be of high quality with good fermentation and proper management of the silo face.

Conclusions

Alfalfa hay and corn silage can both be excellent forages for dairy rations when managed properly. Each has unique carbohydrate characteristics that may complement one another when used together in rations for dairy cows. The nonfibrous carbohydrates in alfalfa and corn silage are very different. Alfalfa contains a significant proportion of pectin; whereas corn silage NFC is predominantly starch. When corn silage is substituted for alfalfa hay in dairy rations there is a small increase in aNDF and decrease in pectin. It is not expected that these ration differences would result in any difference in animal performance, if the corn silage fermentation quality is high and silo management is acceptable.

Forage/Description	CP[a]	EE[b]	Ash	NFC[c]	Star[d]	Pec[e]	aNDF[f]	ADF[g]	ADL[h]
Alfalfa hays									
Exceptional quality	25.4	2.7	10.4	31.5	3.1	14.2	30.0	24.0	4.53
Very high quality	24.0	2.6	9.9	29.4	2.9	13.2	34.1	27.0	5.38
High quality	22.5	2.5	9.5	27.4	2.7	12.3	38.2	30.0	6.23
Good quality	21.0	2.4	9.1	25.3	2.5	11.4	42.2	33.0	7.08
Fair quality	19.5	2.2	8.7	23.2	2.3	10.5	46.3	36.0	7.93
Corn silages									
Very high grain	8.3	3.2	4.1	48.4	31.1	1.9	36.0	21.0	1.57
High grain	8.6	3.1	4.6	43.2	27.2	1.7	40.5	24.0	1.91
Normal	8.8	3.0	5.1	38.1	23.2	1.5	45.0	27.0	2.25
Low grain	9.0	2.8	5.7	33.0	19.2	1.3	49.5	30.0	2.59
Very low grain	9.3	2.7	6.2	27.8	15.3	1.1	54.0	33.0	2.93

[a] Crude protein
[b] Ether extract or crude fat
[c] Nonfiber carbohydrates calculated by difference (NFC = 100 – aNDF – CP – EE – Ash)
[d] Starch
[e] Pectin, estimated from NFC
[f] Amylase-treated neutral detergent fiber determined with sodium sulfite and amylase
[g] Acid detergent fiber
[h] Acid detergent lignin using 72% sulfuric acid

Table 1. Composition of alfalfa hays and corn silages varying in fiber content.